Structural Reform of Transmission Service

Prepared for Rocky Mountain Restructuring:
What Works for the Western States

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May 19, 1999

Why Transmission Reform?

- **To create competitive generation market:**
  - Preferred public policy objective -- EPAct'92
  - Open Transmission Access is a necessary condition
  - Accomplished by "Unbundling" of transmission service from other generation and distribution activities

- **FERC open access Initiatives:**
  - 1994 -- Promulgation of comparable service standard
  - 1996 -- Functional unbundling of industry through open access tariffs under Order Nos. 888/889
  - 1997-98 -- Approval of independent system operators
  - 2000? -- Operational unbundling of industry through Regional Transmission Organizations

Why Regional Transmission Organizations (RTO)?

- **To provide open transmission access over broad areas:**
  - Large, de-pancaked market areas minimize market power in generation.
  - Large scale allows economics of regional power transfers to become a major factor in the expansion of the transmission system.
- **To maintain system reliability and security:**
  - Allow the operator a “wide angle” view of network and matching control authority for the network.
  - Fair and equitable applications of standards to all market participants.

Why do the Western States Care?

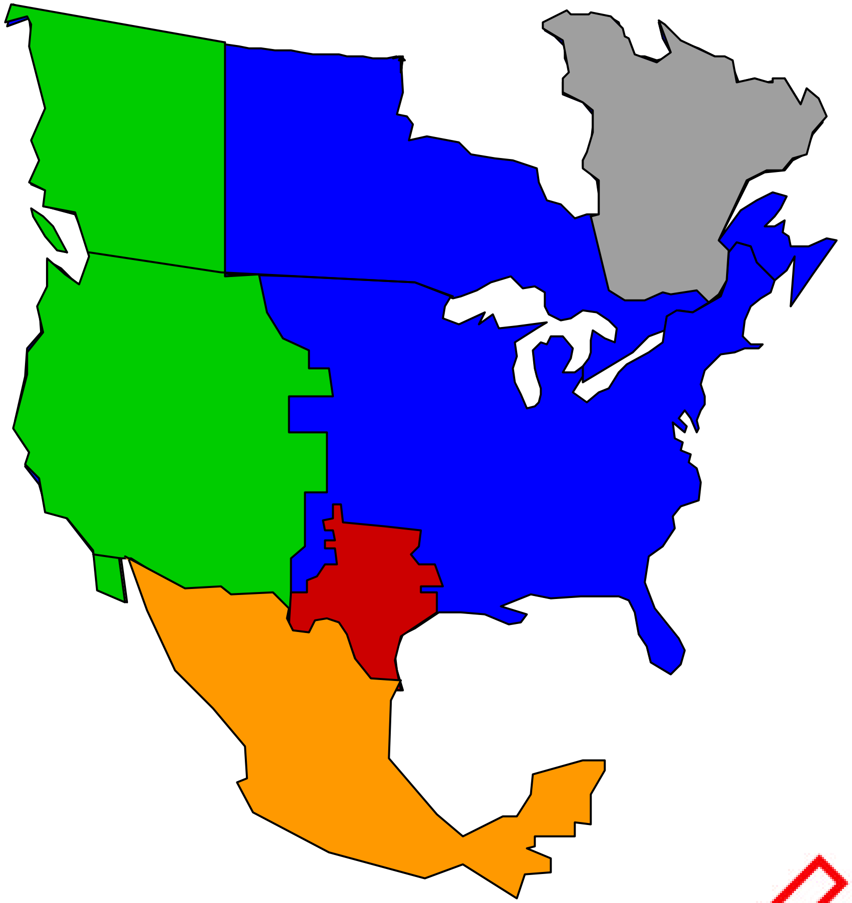
- **The Western transmission system is highly interdependent:**
  - Actions in one part of the network affect all others.
- **The Western electric power market had great potential to benefit from region wide trade:**
  - Seasonal diversity -- Winter Peaking in the North vs Summer Peaking in the South.
  - Resource diversity --
    - Existing Rocky Mountain coal fired resources in Alberta, Montana, Wyoming, Colorado, Utah, Arizona and New Mexico.
    - Existing Pacific Northwest hydro resources in British Colombia, Washington, Oregon, Idaho and Montana.
    - Growing gas fired generation in load centers using pipelines from sources in Canadian Prairies, Wyoming, New Mexico and West Texas.

The Value of Large RTOs

- **Value of large RTOs is shown by a review of system physics and procedures:**
  - The structure of the systems in North America.
  - Basic physics of power flow
    - Loop flow
    - System control
  - Nature of commerce in the electric network
    - Scheduling
    - Flow Control
    - Control Area Operations
    - Pricing Reform

Interconnected Systems

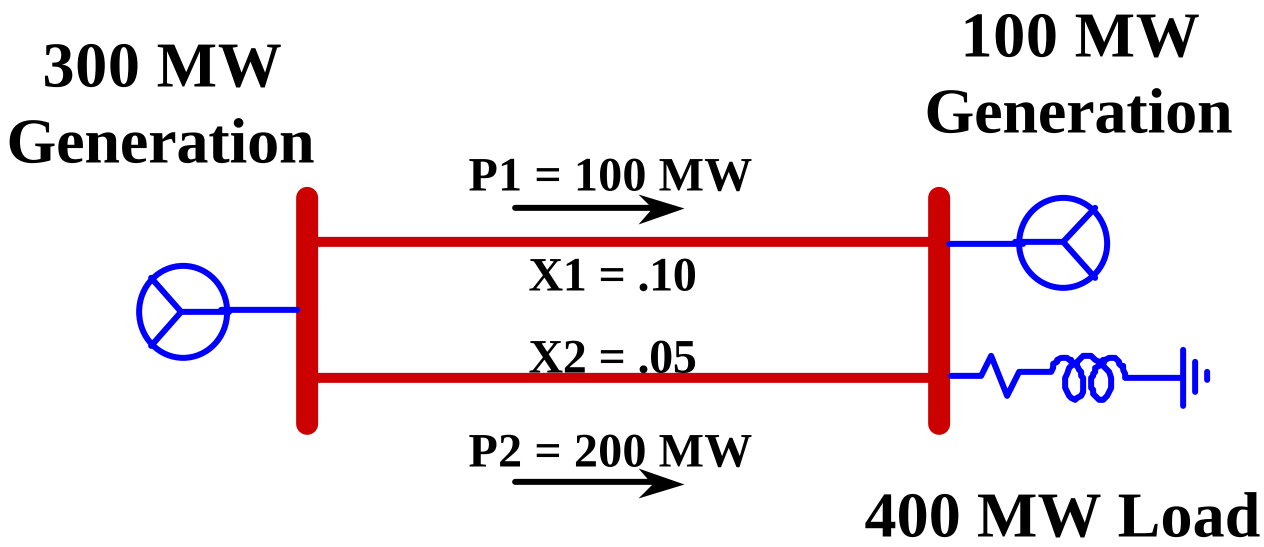
- The five North American Interconnections:
  - Eastern
  - Western
  - Texas
  - Quebec
  - Mexico
- All parts of an interconnection interact with each other:
  - All generators are synchronized, i.e., they operate at the same frequency.
  - AC lines in an interconnection operated in parallel so changes in generation pattern affect all lines simultaneously.
  - Only DC ties exist between the four US-Canada interconnections and no full time ties with Mexico proper.



Loop Flow in the Transmission System

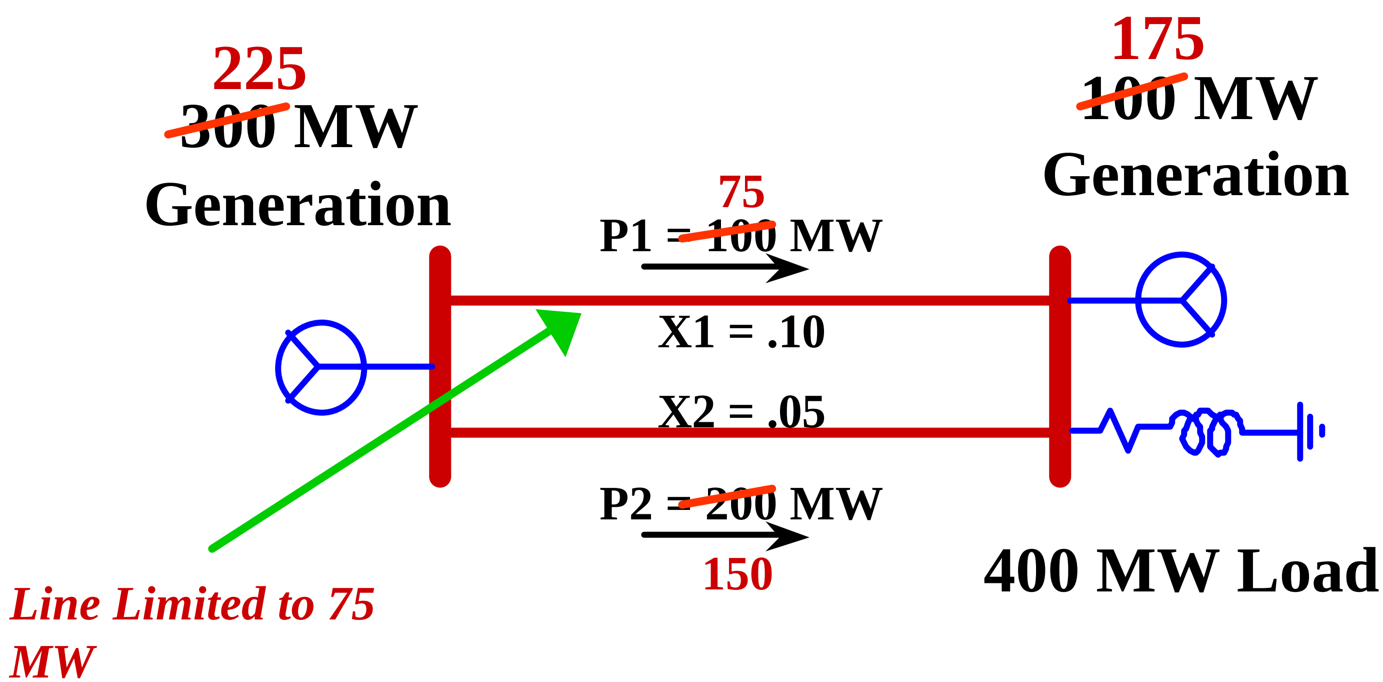
? Power follows the "path of least resistance" according to the laws of physics; more technically, it is inversely proportional to transmission line impedance.

? Simple two line example:



Changing Power Flow on a Transmission Line

- **With limited exception, there are no control devices (the equivalent of valves) to reroute flow between lines.**
- **Flow is primarily controlled by altering the pattern of generation output or occasionally by reducing load.**
- **Two line example with a limitation:**



Full Scale Example: Moving Power in the West

? **100 MW Sale of Wyoming Energy to Southern California:**

   ? 40 MW components flow through Idaho & Montana and down Pacific Coast (Washington, Oregon & No. California).

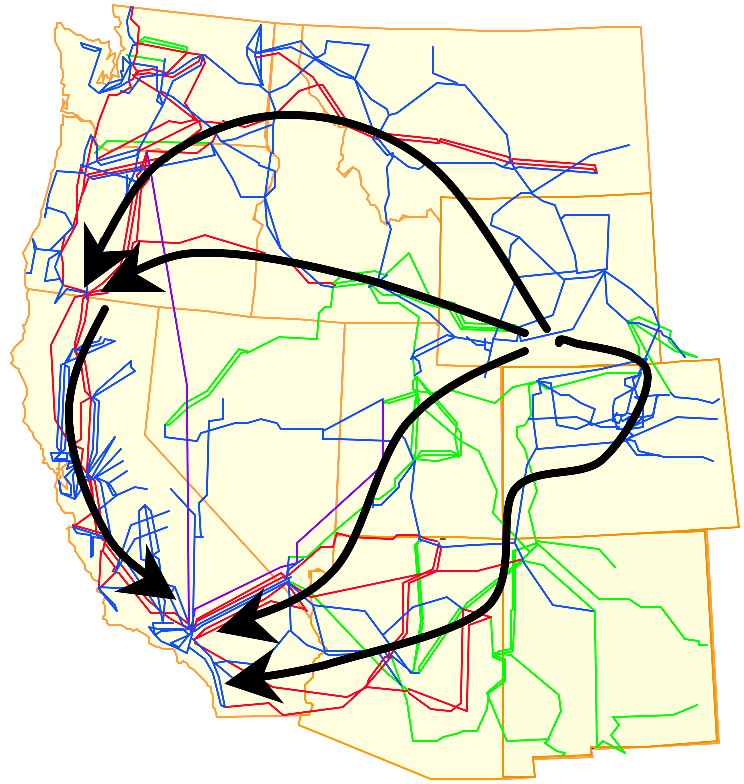
   ? 60 MW components flow through Utah, Colorado, Arizona & Nevada.

? **Observations:**

   ? Today, three transmission providers charge fees on this transaction.

   ? All transactions affect all other systems in the interconnection in varying degrees.

   ? The larger the system, the more control of loop flow effects remains within a single system.



Trading Electricity

- **Electric power is fungible, like cash:**
  - The user can’t tell which supplier produced a kWh consumed.
  - The system is balanced between Control Areas.
- **Energy accounting by Control Areas:**
  - Metered Generation in an hour are “deposits”.
  - Metered Load in the same hour are “withdrawals”.
  - Energy Imbalance for a customer is the net of generation purchased less load supplied, adjusted for losses.
- **Operator corrects energy imbalance by:**
  - Moving generation within Control Area in real time to hold schedules thereby minimizing imbalance with other Control Areas.
  - Buying excess or charging for deficits within Control Area.
  - Adjusts next day’s schedules to rebalance books.

Scheduling Power

? **Scheduling is the process used by the system operator which connects electricity trade to physical system control.**
  ? Day-Ahead: Adjacent Control Areas agree on imports and exports (net interchange) which is to occur for each hour for the following day.
  ? Hour-Ahead: Adjustments made prior to the actual hour for changes which have occurred during the day.
  ? Real-Time: Adjustments made within the actual hour to meet unexpected events, e.g., loss of generator or line.

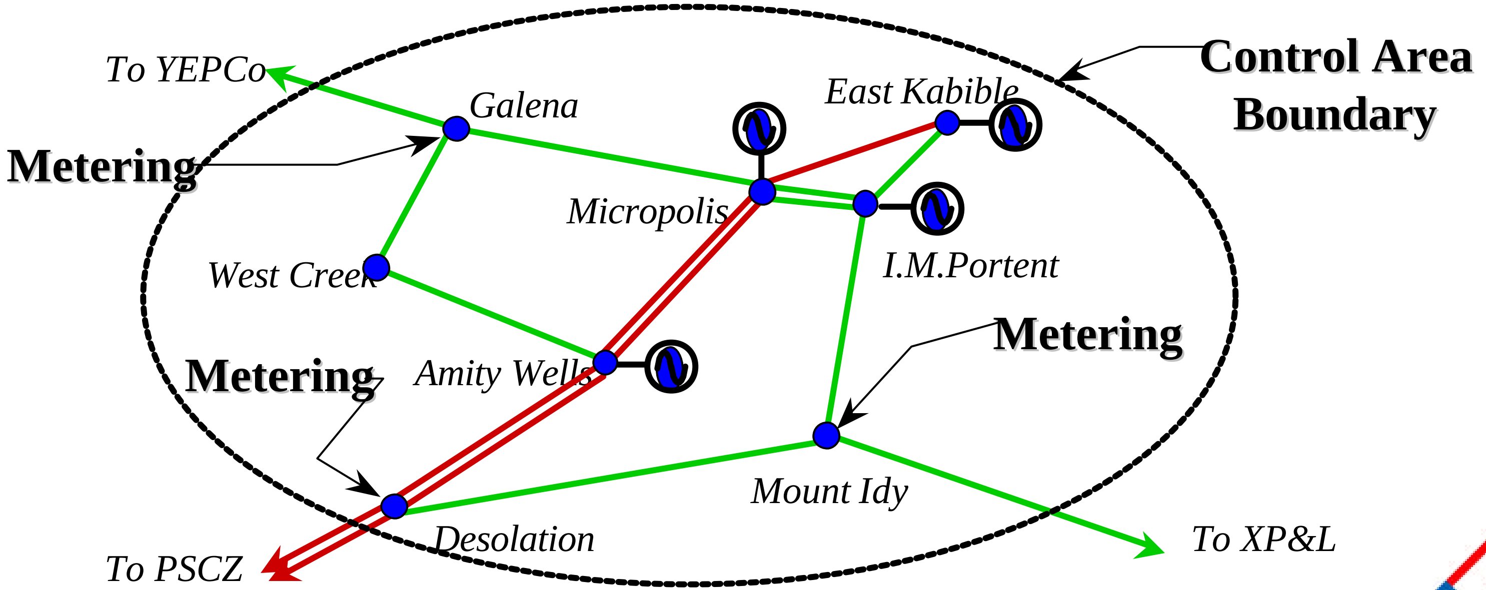
? **All Control Areas involved in a transaction must be notified and must agree to a scheduled transaction.**

Line Flow Management

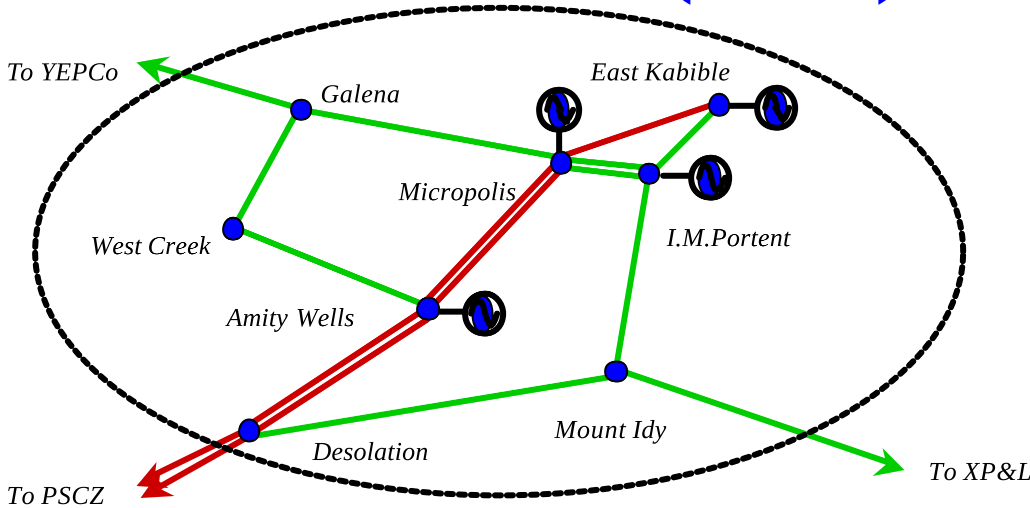
- **If proposed schedules or an operational event exceeds rated transfer capability of lines, the operators can:**
  - Deny use of system -- “Curtail or Cut Schedules”.
  - Depart from least cost dispatch and adjust generation at one location against generation at another location to alter the necessary flows -- “Congestion Relief by Redispatch”.
- **Reliability Standards set safe limits on transfer capability based on planning for contingencies:**
  - Forced outage of generators --
    - Reserve generation on line and not loaded.
    - Reserve shared across the system -- mutual benefit.
  - Line outages due to faults (short circuits) --
    - Loss of a single line will not overload any other line in the system.
    - The failure of multiple lines will not result in cascading outages.

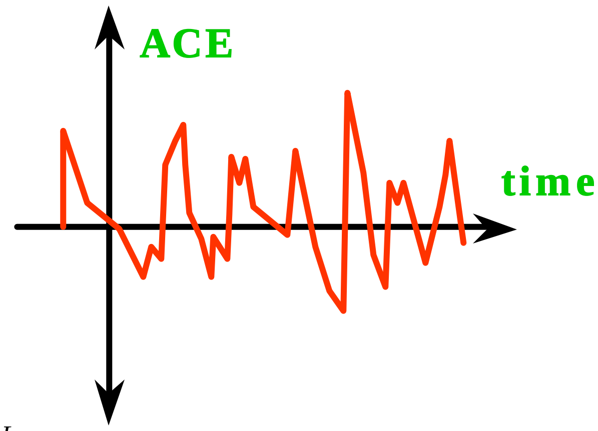
An Example Control Area

- **Basic Principles:**
  - Control Area meters power lines crossing its boundary to establish the amount of power interchanged.
  - Interchange = Generation - (Load + Losses)



Area Control Error (ACE)





? **ACE = Actual Interchange - Schedule Interchange**

? **NERC Operating Standards:**

  ? ACE must be zero once at least every ten minutes.

  ? Average deviation must be within specified limits.

? **Operator must have control of generation in real time.**

  ? Today, a control area owns the generation it uses for control.

  ? Under an RTO, generation control achieved by contracts with generators who are independent of the RTO.

Pricing Reform

- **Traditional Postage Stamp Pricing:**
  - Average cost per kW of peak load for each owner's facilities.
  - Wheeling charges "pancake", i.e., they are the sum of the "postage stamps" for each system across which the transaction is scheduled.
  - The congestion created by loop flow not directly addressed.
- **Enabling Transmission Pricing Reform:**
  - Combine small system charges under a single fee structure.
    - Used to collect majority of fixed costs from access fees.
    - "License plates" concept used to resolve price shifting concerns.
  - Institute congestion pricing over large areas.
    - "Zonal hubs and inter-zonal spokes".
    - Loop flow addressed by pricing congestion with RTO.
    - Price coordination between RTOs at hubs.

Hypothetical Transaction -- Today

- **During an uncongested hour, 150 MW of a So. Cal. Muni's load is served by a Wyoming independent generator.**
- **Generator produces 170 MWh for $10/MWh**
  - Control Areas Schedules:
    - Generator moves 170 MWh to WAPA
    - WAPA moves 162 MWh PacifiCorp ($3/MWh & 5% losses)
    - PacifiCorp moves 158 MWh to APS ($2/MWh & 3% losses)
    - APS moves 153 MWh to LADWP ($2/MWh & 3% losses)
    - LADWP moves 150 MW to Muni ($3/MWh & 2% losses)
  - So. Cal. Muni receives 150 MW at cost of $21.7/MWh
    - Energy = 170 MWh @ $10/MWh = $1,700
    - Wheeling = (150@$3) + (153@$2) + (158@$2) + (162@$3) = $1,558
    - Effective Rate = ($1700 + $1558) / 150 MWh = $21.7/MWh

Hypothetical Transaction -- w/Large RTO

- **During an uncongested hour, 150 MW of a So. Cal. Muni's load is served by a Wyoming independent generator.**
  - Generator produces 162 MWh for $10/MWh.
  - Control Areas Schedules:
    - Generator moves 162 MWh to "InterWest Transco"
    - "Interwest Transco" moves 156 MWh to CA-ISO ($2/MWh & 4% losses)
    - CA-ISO to Muni ($0MWh & 4% losses)
  - So. Cal. Muni receives 150 MW at cost of $12.9/MWh ($10.8/MWh with inter-ISO reciprocity agreement on "exports fees").
    - Energy = 162 MWh @ $10/MWh = $1,620
    - Wheeling = (150@$0) + (156@($2+$0)) = $312
    - Effective Rate = ($1620 + $312) / 150 MWh = $12.9/MWh

Issues Addressed by RTOs

- **Generation Market Power Issues:**
  - Pancaking of fixed cost access charges eliminated over wide area.
  - Expanded market scale increases the number of potential competitors with simplified transactions.
  - Price transparency achieved for the cost of system congestion.
- **System Reliability:**
  - Loop flow is internalized as smaller control areas are merged.
  - Loop flow between RTOs can be managed under protocols driven by congestion pricing.
  - Scale of operations lowers O&M cost without loss of reliability.
  - Regional power market, not just local interest, drives system expansion.

What Kind of RTO -- A Transco?

- **Independent Transmission Company (Transco)?**
  - Transco offers firm service by taking on <u>delivery risk</u>:
    - Congestion cost is internalized for firm transmission services;
    - Transco can deal with complexities of interactions between it and other transmission service providers; and
    - Since transco bears delivery risk, it has incentives to economically expand the network.
  - Profit incentives drive Transco to:
    - Optimize use existing network within reliability standards by driving up energy throughput and controlling costs, and
    - Expand the network to meet customer demand when investment can be justified by reduced congestion cost.

What Kind of RTO -- An ISO?

? **Independent System Operator (ISO)?**

? ISO cannot take delivery risk:

? Without an asset base to work against, congestion cost must pass through to customers;

? Firm service over congested facilities can only be approximated by Transmission Congestion Contracts;

? Since customers bear delivery risk, they must be responsible for network expansion; and

? Dispersed expansion responsibility requires agreement by many parties, some of whom benefit from status quo.

? ISO focused is:

? Primarily on optimization of existing network, and

? Secondarily on facilitating network expansion by others.